PILOT PLANT INVESTIGATION ON THE BRIQUETTING AND CARBONISATION OF SOUTH ARCOT LIGNITE

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1. INTRODUCTION

The Neyveli Lignite Corporation Ltd. are now implementing an Integrated Project for the development of lignite resources at Neyveli, Madras State, India. The lignite bearing area here is 100 square miles and the reserves are estimated at 2,000 million tons (1). Tests done at Neyveli and other laboratories have indicated that the lignite is of very good quality and that it could be briquetted without a binder. Table 1 gives the analysis of South Arcot lignite.

In the first stage of development, the Integrated Lignite Project consists of the following schemes:

1) An Open Cast Mine, for producing 3.5 million tons of lignite per annum.

2) A Thermal Station with an installed capacity of 250 M.W. The Thermal Station will burn pulverised raw lignite as fuel.

3) A Fertilizer Plant for producing 152,000 tons of urea per annum by the total recycle process. This plant is expected to be the biggest of its kind in the world.

4) A Briquetting and Carbonisation Plant for producing 380,000 tons of carbonised briquettes per annum. This will be one of the biggest lignite briquetting and carbonisation plants in the world. The carbonised lignite briquettes will be used mainly as domestic fuel in South India.

When the Corporation started the development of lignite resources, it did not have adequate data to decide upon the type of equipment that should be used for drying, briquetting and carbonisation of lignite. It was considered risky to base the design of a large commercial unit on laboratory data alone. Too, experiments conducted in Germany showed that it was not possible to conduct pilot plant tests on drying, briquetting and carbonisation at any one place, because all the equipment were not available in any one laboratory. The technical opinion was that the weather had a significant role to play in these processes and the best thing would be to conduct pilot plant tests at Neyveli itself. Accordingly, a pilot briquetting and carbonisation plant was installed at Neyveli. This was erected in a record time of eight weeks and was put into commission on the 14th May, 1958.

2. DESCRIPTION OF THE PILOT PLANT:

The pilot plant consists of a raw coal preparation section, a Parry dryer in which the lignite is dried in an entrained state by hot inert gases, an extrusion type briquetting press made by Messrs. Pawert AG. of Switzerland and a carboniser designed by the U.S. Bureau of Mines. It also has tar and gas collecting systems. The arrangement of the major equipment in the Pilot Plant is shown in figure 1. The plant was supplied by the Technical Co-operation Mission (U.S.A.).

The raw coal preparation section has a hammer mill with a throughput of 3 to 5 tons of raw lignite per hour. The dryer can handle upto 2.5 tons of raw lignite per hour, when drying lignite from 56% to 10% moisture. The briquetting press can make briquettes of two nominal sizes, 65 mm. (2½") diameter and 38 mm. (1½") diameter. The capacity of the press, when it makes 65 mm. diameter briquettes, is about 1 ton of briquettes per hour. When it makes 38 mm. diameter briquettes, the press capacity is of the order of 1000 lbs. per hour.

The carboniser was designed to carbonise continuously about 300 to 500 lbs. of raw briquettes per hour. However, it was found during actual practice that it was difficult to obtain satisfactory performance, when the carboniser is operated on a continuous basis. Such an operation gave too many fines in the product. Batch tests have been done, using charges of the order of 1000 to 2000 lbs. of raw briquettes at a time.

3. DESCRIPTIONS OF THE RUNS MADE IN THE PILOT PLANT

Since the pilot plant came into operation, 26 runs on the dryer, 77 runs on the briquette press and 44 runs on the carboniser have been made. The aim of the investigations was to find out the optimum drying, briquetting and carbonisation conditions for producing good carbonised briquettes for use as domestic fuel in South India. The carbonised briquettes are expected to take the place of charcoal, which is a commonly used domestic fuel in South India at present. Due to scarcity of charcoal, the need for a substitute fuel is keenly felt. Under the prevailing conditions, the fuel that is to replace charcoal has to be, as much as possible, similar to charcoal in handling and combustion properties. Otherwise, there is a likelihood of consumer resistance. The volatiles in the carbonised briquettes have to be low enough to cause no smoke in actual use, but high enough to facilitate easy ignition of the fuel. The carbonised briquettes also must have fairly strong structure, such that they can be transported over a distance of 200 to 300 miles, without appreciable amount of degradation in size.

The variables that were investigated, were the following:-

1) Size of the dried lignite for briquetting.
2) Moisture in the raw briquettes.
3) Size of the raw briquettes.
4) Temperature of carbonisation.
5) Heating rate during carbonisation.
6) Method of quenching of carbonised briquettes.
7) Influence of ash on the strength of carbonised briquettes.

Laboratory scale experiments (2,3) indicated that best briquettes for carbonisation could be produced by taking fine dried lignite with as low a moisture content as possible and pressing it with as high a pressure as possible. No binder is required for briquetting. However, some evidence showed that better briquettes were obtained when the dried lignite had a size of 0-2 m.m. rather than 0-1 m.m. (4). The arrangements in the coal preparation section of the pilot plant was such that much control could not be exercised on the sizing of raw crushed lignite. The only control that could be had was on the shape, size and number of hammers in the hammer mill. Initially the mill was designed to operate at 3000 RPM., which gave too fine a material for drying and briquetting. The very fine dried lignite powder that was produced could not be briquetted in the extrusion press. The speed of the hammers was then changed to 1450 RPM., which gave better results. Table 2 gives typical sizes of the product from the hammer mill before and after the changes were incorporated in the mill. The best briquetting results were obtained when the -200 mesh material of crushed raw lignite was of the order of 3 to 4%. When the -200 mesh material was of the order of 9 to 10% in the crushed raw lignite, the -200 mesh material in the product was of the order of 33 to 34%. This dried lignite was too fine to be briquetted in the extrusion press of the Pilot Plant. When the

-200 mesh material in the dried lignite was of the order of 18%, as was the case after the modifications were carried out in the hammer mills, the dried material could be briquetted easily in the press.

Moisture in the raw briquettes plays a significant role in the production of good carbonised briquettes. Laboratory tests indicated that the lower the moisture content in the raw briquettes, the stronger and better were the carbonised briquettes. However, in actual practice there is a limitation to the minimum moisture content in the dried lignite, which is used for briquetting. Very low moisture in the lignite will make it difficult to handle in the conveyors and briquette presses. It also produces a great fire hazard. High moisture content in the raw briquettes will result in weak carbonised briquettes. Sometimes the raw briquettes themselves will be weak. Experiments in the extrusion press installed at Neyveli indicated that when the moisture content in the dried lignite is of the order of 10 to 14 percent, good raw briquettes could be made. Actual experiments in the carboniser have indicated that briquettes with 12% moisture and below give good carbonised briquettes. Table 3 gives the yield of whole carbonised briquettes, when the moisture content varied from 10 to 17%. The data are clear that when the moisture content in the raw briquettes is between 11.7 and 12.7%, the number of whole carbonised briquettes is large.

The size of raw briquettes plays a role in the production of lumpy carbonised briquettes. For actual household use in South India, the briquettes need not be of very large size at all. The preferable thing would be to have a briquette which would be of 25 to 38 mm. in diameter and 25 to 38 mm. in thickness. Two sizes of briquettes were investigated in the Pilot Plant, viz. 65 mm. and 38 mm. (diameter). The thickness of the briquettes in both cases varied from 25 to 40 mm. It was found that invariably the yield of whole carbonised briquettes was higher with the 38 mm. raw briquettes. It was possible, in batch tests, to obtain almost hundred percent unbroken carbonised briquettes with a charge of raw briquettes of 38 mm. diameter. Tables 3 and 4 give these results.

The design of the carboniser was such that it was difficult to measure the exact carbonisation temperature. The measurement was made of what is called "gas cross-over temperature". This temperature varied from 600° F to 1210° F during the tests under discussion. The carbonisation temperature was approximated from the volatile matter content in the carbonised briquettes. When the carbonisation temperature was about 650° C, the volatile matter in the carbonised briquettes was of the order of 15 to 18% (moisture and ash free). These briquettes gave a smokeless flame and had good combustion properties. Lower temperatures yielded carbonised briquettes which had higher percentage of volatiles, which resulted in these briquettes giving smoky flame. It was not possible to raise the gas cross-over temperature of the carboniser beyond 1210° F. This corresponds to a carbonisation temperature of about 750° C. The minimum volatile matter in the carbonised briquettes obtained during these tests was 8.5% (m.a.f.). The rate of heating was critical in all cases. The heating had to be as slow as possible upto about 250° C. Beyond that, the charge could be heated at a faster rate. Figure 2 gives typical heating curves during these carboniser runs. The heating time in these runs varied from 6 to 21 hours.

In commercial operations, two types of quenching are used for cooling the carbonised briquettes, dry quenching with inert gases and wet quenching with water sprays. Dry quenching methods are generally more expensive. Table 5 lists the results obtained during dry quenching and wet quenching of carbonised briquettes made under identical conditions. The investigations showed that as far as the size of the carbonised briquettes is concerned, the method of quenching had no significant effect. The only difference was that wet quenching increased the moisture content in the carbonised briquettes.

The ash content in the raw lignite has a great influence on the quality of briquettes. The ash content in the raw lignite that was used in these tests varied from 2.8% to 7.3%. As far as can be seen from the data collected during these runs, although the variation in ash content did not have a pronounced effect on the shatter index of carbonised briquettes, yet it greatly influenced the tumbler index. Table 6 indicates these results.

Table 7 gives the physical properties of raw briquettes and carbonised briquettes. The chemical and physical properties of these carbonised briquettes are similar to those produced in Germany (5) and correspond to the properties of charcoal used in South India (6).

4. SUMMARY

Pilot Plant investigation on the drying, briquetting and carbonisation of South Arcot lignite showed that good carbonised briquettes could be produced for use as domestic fuel. Optimum conditions for drying, briquetting and carbonisation were established.

5. ACKNOWLEDGMENT

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TABLE 1 - ANALYSIS OF SOUTH ARCOT LIGNITE

a) Proximate analysis:

Moisture	%	51.00 - 56.00
Ash	%	2.20 - 3.30
Volatile matter	%	22.40 - 24.93
Fixed Carbon	%	19.10 - 20.59

b) Ultimate analysis:

Carbon	%	29.48 - 33.60
Hydrogen	%	2.07 - 2.40
Nitrogen	%	0.24 - 0.29
Oxygen	%	8.63 - 9.21
Sulphur	%	0.29 - 0.48
Ash	%	2.20 - 3.30
Moisture	%	51.00 - 56.00

c) Calorific value:

Gross:	k.cal/kg	2560 - 3165
Net:	k.cal/kg	2307 - 2902

TABLE 2 - SIZE ANALYSIS OF CRUSHED RAW LIGNITE AND CORRESPONDING SIZE ANALYSIS OF DRIED LIGNITE

Sieve No. (Tyler)	Size of opening mm.	Before changing hammers and reducing motor speed			After changing hammers and reducing motor speed		
		Crushed raw lignite	Dried lignite		Crushed raw lignite	Dried lignite	
			Sample I	Sample II		Sample I	Sample II
		Cumulative weight %	Cumulative weight %	Cumulative weight %	Cumulative weight %	Cumulative weight %	Cumulative weight %
4	4.699	13.4	—	—	10.21	—	—
8	2.362	28.8	—	—	31.05	—	—
16	0.991	57.8	3.20	7.45	57.03	6.12	6.63
28	0.589	63.2	15.82	22.00	68.37	22.48	24.34
48	0.295	76.6	37.22	38.50	79.38	48.38	49.28
60	0.246	78.6	42.04	42.15	82.40	52.50	53.19
80	0.175	83.0	49.09	48.25	87.25	62.82	63.30
100	0.147	86.1	54.41	53.40	93.23	68.44	69.44
200	0.074	91.0	66.06	65.82	96.55	81.25	81.03
-200	0.074	9.0	33.94	34.18	3.45	18.75	18.97
Moisture %		50.3	11.70	9.80	49.2	12.8	12.00

TABLE 3 - INFLUENCE OF MOISTURE ON THE YIELD OF CARBONISED BRIQUETTES.
(Size of raw briquettes - 65 mm.)

Moisture in the raw briquettes %	Yield of full briquettes %
17.2	9.7
16.2	17.2
13.6	29.9
12.7	49.6
12.0	53.0
11.7	48.0
11.4	38.0
11.0	35.7

TABLE 4 - YIELD OF WHOLE CARBONISED BRIQUETTES
(from 38 mm. raw briquettes)

Carboniser run	7	8	15	16	17*
Temperature - Gas cross-over °F	775	700	775	700	630
Size of raw briquettes - diameter in mm.	38	38	38	38	38
Moisture in the raw briquettes %	11.4	11.4	11.6	10.4	12.0
Yield of carbonised briquettes:					
+ 25 mm. %	100	100	100	100	94
- 25 mm. %	—	—	—	—	6

*The temperature at the time of charging briquettes in run No. 17 was 460° F. This explains the lower yield of full briquettes.

TABLE 5 - INFLUENCE OF METHOD OF QUENCHING ON THE SIZE AND STRENGTH OF CARBONISED BRIQUETTES.

Run No.	33		34		35		36	
	Gas quenched	Water quenched	Gas quenched	Water quenched	Gas quenched	Water quenched	Gas quenched	Water quenched
Raw briquettes:								
Moisture %	11.4		11.0		13.2		13.2	
Ash %	14.4		13.8		8.2		8.2	
Carbonised briquettes:								
Temperature of gas cross-over °F	700		700		645		700	
+ ½" % of product	80.2	86.7	80.9	80.7	96.6	96.4	94.1	92.3
Compression strength kg/cm²	120	112	162	186	181	164	160	167
Moisture in carbonised briquettes %	2.1	4.5	1.5	3.4	1.9	9.0	1.3	4.0

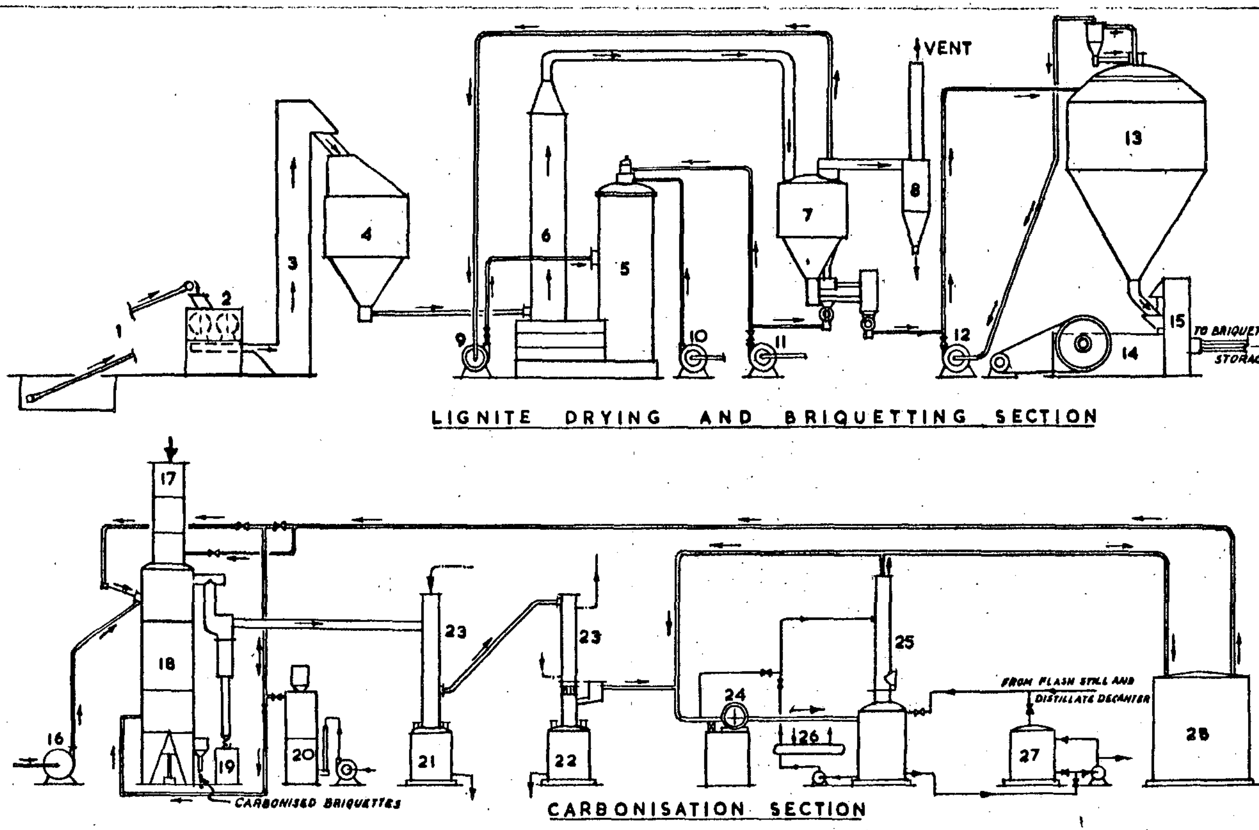
TABLE 6 - INFLUENCE OF ASH ON THE STRENGTH OF CARBONISED BRIQUETTES.

Run Nos.	30	17	20	4	25*	33
Raw briquettes:						
Moisture %	12.4	12.0	12.0	12.7	13.2	11.4
Ash %	5.9	7.5	8.2	8.9	9.4	14.4
Ash (Moisture free)	6.7	8.5	9.4	10.4	10.7	15.5
Shatter index + 3/4" %	87.5	90.3	93.5	86.7	86.2	84.8
Tumbler index + 3/4" %	82.6	76.1	72.4	67.6	57.4	62.5

*Low tumbler index in this run is due to the cumulative effect of high moisture and ash.

TABLE 7 - PROPERTIES OF RAW AND CARBONISED BRIQUETTES

		Raw briquettes (South Arcot lignite)	Carbonised briquettes (South Arcot lignite)	Charcoal (6)	Lignite char from Boehlen (5)
Moisture	%	11.5 - 12.5	1.0 - 3.5	4.54	3.1
Ash	%	5.9 - 8.2	11.2 - 15.8	4.55	24.4
Volatile matter	%	40.6 - 44.2	13.5 - 15.6	13.01	11.8
Fixed carbon	%	35.4 - 40.5	70.8 - 73.6	77.90	60.7
Calorific value	Kcal/kg.	5120 - 5650	6250 - 7020	7100	6167
Shatter test	+ 3/4" %	89.2 - 94.6	91.0 - 96.2	82.40	—
Tumbler test	+ 3/4" %	78.2 - 82.6	74.8 - 80.2	70.3	—



1 RAW LIGNITE CONVEYOR	8 STACK CYCLONE	15 SPILL ELEVATOR	22 NO. 2 TAR DECANTER
2 HAMMER MILL	9 RECYCLE BLOWER	16 PROCESS AIR BLOWER	23 PPIMARY & SECONDARY CONDENSERS
3 BUCKET ELEVATOR	10 FORCED DRAFT BLOWER	17 CHARGING BUCKET	24 NASH HYTOR
4 RAW LIGNITE BIN	11 PRIMARY AIR BLOWER	18 CARBONISER	25 GAS SCRUBBER
5 DRYER FURNACE	12 TRANSPORT BLOWER	19 ASH BARREL	26 NASH SEALANT COOLER
6 DRYING COLUMN	13 DRIED LIGNITE BIN	20 GAS PRODUCER	27 SCRUBBER OIL STORAGE
7 PRIM. & SEC. SEPARATORS	14 BRIQUETTING PRESS	21 NO. 1 TAR DECANTER	28 GAS HOLDER

FIG:-1. SCHEMATIC DIAGRAM OF THE PILOT BRIQUETTING & CARBONISATION PLANT

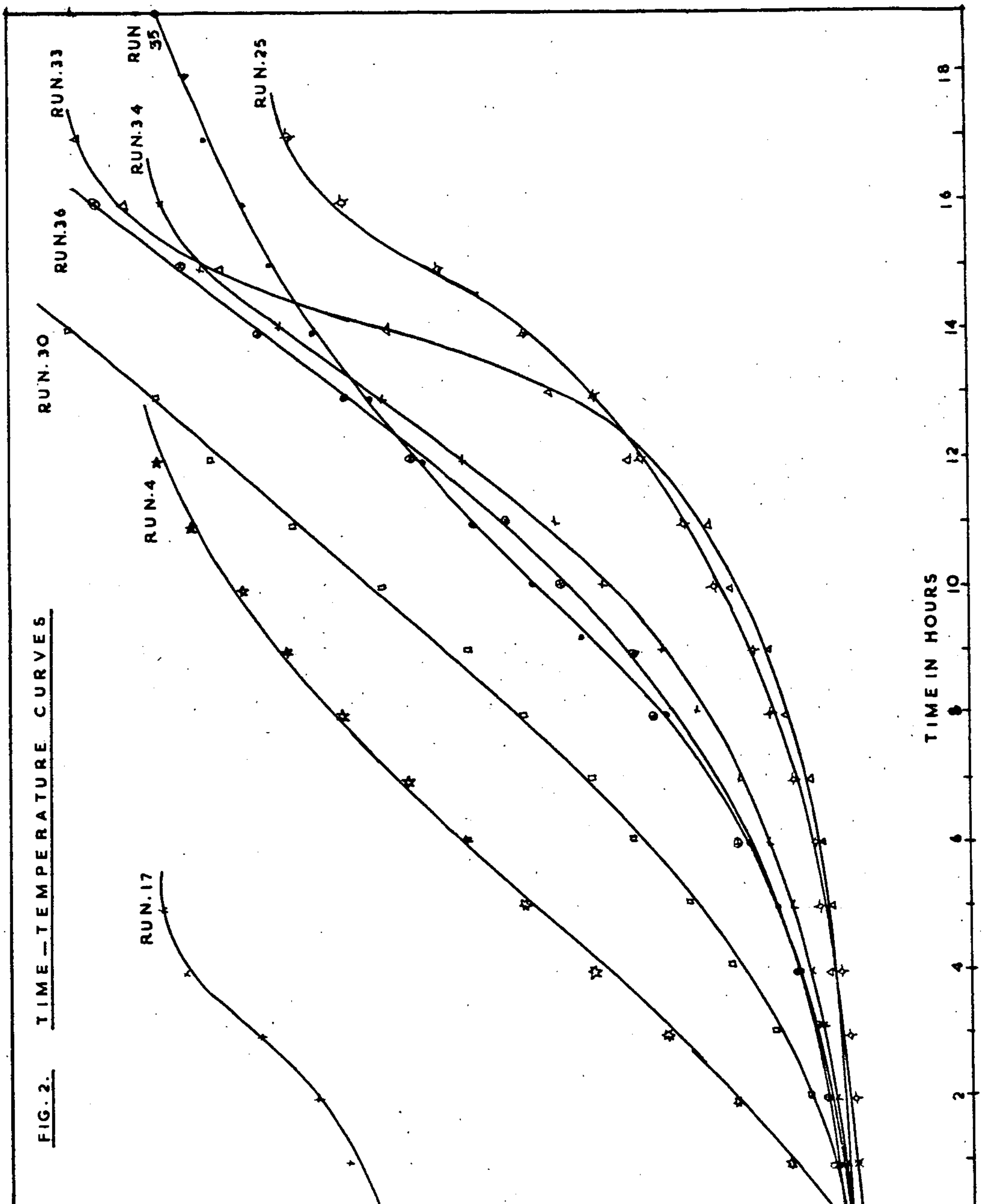


FIG. 2. TIME — TEMPERATURE CURVES